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Sorghum

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SORGHUM.

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I. Improvement by Selection.

The work begun here in 1888 aiming at the improvement of the sorghum plant as a sugar bearer was continued during the season of 1889 with the results recorded below.

Our mode of work, fully described in Bulletin No. 5, is by selection of seed from those individual stalks found by analysis to be richest in sugar and highest in purity of juice, for future planting.

In this manner there were selected in 1888 from 180 stalks analyzed, ten whose juice showed an average purity of 73.4 with a mean sucrose content of 13.92 per cent., single polarization, and ten more with an average purity of 73.7 and of 13.63 per cent. surcose.

The average polarization for the entire 180 was only 12.10 per cent. sucrose on the juice; purity of the latter unknown.

The variety was Early Amber.

The seed from these selected canes, graded according to quality, was planted last spring in several plats of about ⅛ acre each, with the intention of examining many stalks from each plat in the autum, for the information that might be yielded even if *selection of seed* from all might not be found advisable; but the season proved so unfavorable, both for the early growth and the maturing of sorghum, that when autumn arrived it was not thought worth while to examine any but the "best" patch; and for even this, scant time was allowed by the frosts after the crop reached maturity.

The early part of the season was dry and the latter part, when the plant needs abundant warmth for the development of sugar, was unusually cold; hence the season as a whole was considered unfavorable to sorghum.

For this reason no one was surprised when upon examination the increase in sugar content over that of 1888 was not found to be great—in fact, the only surprise was that there was any improvement at all.

Systematic analysis of the stalks was not begun until Sep. 11th, the cane even then being no more than mature.

On the night of Sept. 18th there came a killing frost which within three days withered the cane leaves and soured the sap in the stalks, thus reducing our season for selective work to only ten days.

In this limited time and with the help available it was only found possible to analyze 175 individual stalks; and of these the last 29 tested (on Sept. 21st) were plainly deteriorated, leaving only 146 sound stalks.

They were all from our "best" patch of Early Amber, excepting six stalks of Early Orange which also were from seed selected by analysis the previous year.

The juice of all canes analyzed was expressed by double milling with a 3 roll hand mill; methods of analysis same as described in Bulletin No. 5. The detailed results of the ten days' work would fill many pages of this bulletin, therefore I will summarize.

Results.

On the 140 stalks of unfrosted Early Amber the 10 showing highest sucrose content gave the following figures:

On Single Cleaned Canes.

Number.	Per cent. Juice.	ON THE JUICE.		
		Solids. Brix at 17½ C.	Sucrose, single polarization.	Purity coefficient.
		per cent.	per cent.	
1	50.35	20.44	14.87	72.76
2	48.10	18.87	14.47	76.15
3	50.60	19.57	14.41	73.63
4		18.23	14.39	78.38
5	47.50	20 04	14.38	71.75
6	38.20	17.70	14.37	81.18
7		17.98	14.36	79.86
8		19.39	14.35	74.00
9		18.93	14.33	76.22
10		18.26	14.31	78.37
Average.	47.00	18.94	14.42	76.15

The 10 showing next highest sucrose gave:

On Single Cleaned Canes.

Number.	Per cent. Juice.	ON THE JUICE.		
		Solids. Brix at 17½° C.	Sucrose, single polarization.	Purity coefficient.
		per cent.	per cent.	
1		19.12	14.28	74.69
2		18.06	14.23	78.80
3	44.50	18.67	14.20	76.05
4	54.80	18.34	14.20	77.42
5		18.06	14.13	78.23
6	64.20	17.84	14.12	79.14
7		18.93	14.11	74.53
8		18.02	14.01	78.08
9	49.40	18.93	14.01	74.01
10	53.90	17.84	14.01	78.53
Average.	53.36	18.38	14.11	76.76

These tables well illustrate the fact that neither the percentage of sucrose in the juice, nor even its absolute amount in the entire cane is *alone* an accurate measure of the quality of the latter.

This is shown most forcibly by a comparison of certain individual canes, some of which with lower percentage of sucrose in the juice than others are really superior to them either because of higher purity or because of a larger percentage of juice in the stalks.

For these reasons a number of the second ten are probably better to propagate from than some in the first or "highest sucrose" ten.

The following table exhibits first, the average results for the 10 "lowest" and the 10 "next lowest" of the 140 Early Amber stalks; next, for comparison, the averages already given for the 10 "highest" and the 10 "next highest;" and lastly, the average of the results on the entire 140 canes—with the exception that the figure for *percentage of juice* is the average on 79 stalks instead of 140.

Summary of results on 140 Early Amber Canes: (1)

	Per cent. Juice.	ON THE JUICE. Solids. Brix. per cent.	Sucrose, single polarizat'n per cent.	Purity coefficient.
Av. 10 "lowest" canes.	53.06	16.47	10.86	65.94
Av. 10 "next lowest" canes.		17.14	12.09	70.50
Av. 10 "highest" canes.	47.00 (2)	18.94	14.42	76.15
Av. 10 "next highest" canes.	53.36 (2)	18.38	14.11	76.76
Av. 140 canes.	52.94 (3)	17.80	13.18	74.04

1 Topped and stripped.
2 Av. on 5 stalks instead of 10.
3 Av. on 79 stalks instead of 140.

Glucose was determined on only 27 of 140 Early Amber canes, and on 2 of Early Orange, The results are all between 1.16 and 1.97 per cent (on the juice), the mean being 1.57—figures which can only be regarded as very gratifying, since they show considerably less glucose than has usually been found in sorghum, and only about *one-half* as much as the average found in our Early Amber of 1888.

Results of 1888 and 1889 Compared.

To show what evidence there is, if any, of improvement by selection, the analytical results of the two years will now be compared.

Average of 20 Stalks showing Highest Sucrose, for 1888 and 1889.

	Per cent. Juice.	ON THE JUICE. Solids. Brix. per cent.	Sucrose, single polarization. per cent.	Purity coefficient.
1888.	54.05	18.70	13.77	73.55
1889.	50.18*	18.66	14.26	76.45

*Av. of only ten stalks instead of twenty.

Taking into account the larger yield of juice in 1888, these figures show perhaps no real gain in sucrose for the entire canes; but in purity of juice the gain is very marked.

The same advance in purity is found in comparing the 20 stalks lowest in sucrose for the two years, thus:

Average of 20 Stalks Lowest in Sucrose for 1888 and 1889.

	Per cent. Juice.	ON THE JUICE. Solids. Brix. per cent.	Sucrose. single polarization. per cent.	Purity coefficient.
1888.	58.42	15.45	9.28	59.40
1889.	52.18*	16.80	11.47	68.24

*Av. of only 9 stalks instead of 20.

The average results on all selected canes analyzed in 1888 are not as complete as could be wished, but as far as they go comparison between them and similar averages for 1889, show along with a notable increase in sucrose a rather remarkable and very gratifying falling off in glucose.

Number of stalks analyzed in 1888=180.

Number of stalks analyzed in 1889=146.

Averages for all Individual Canes analyzed in 1888 and 1889.

	Per cent. Juice.	ON THE JUICE. Solids. Brix. per cent.	Sucrose, single polarizat'n per cent.	Purity coefficient	Glucose. per cent.
Av. for 1888.	54.66		12.10		3.31†
Av. for 1889.	52.94*	17.79	13.18	74.11	1.57‡

*Av. of 79 stalks.
†Av. of 32 stalks.
‡Av. of 27 stalks.

The question naturally arises whether the smaller amount of glucose found in 1889 may not have been due to the greater maturity of the cane.

That may be the true explanation; but that such is the case seems improbable from the fact that sorghum in general was in this locality no earlier in maturing the second year than the first, and the analysis of cane happened to be begun on the same day of the month each year.

Early Orange.

Only six individual stalks of Early Orange were analyzed in 1889, incidentally to the main work on Early Amber. They were from a small patch grown from a few seeds selected the year previous from only 14 stalks which were indvidually analyzed that year.

Results on Early Orange for 1888 and 1889 compared:

Early Orange for 1888 and 1889.

	Per cent. Juice.	ON THE JUICE.		
		Solids. Brix.	Sucrose, single polarization.	Purity coefficient.
		per cent.	per cent.	
14 stalks, 1888	55.84	17.20	12.10	70.35
6 stalks, 1889	55.87	17.65	13.35	75.60

Here again notable increase in sucrose is observed accompanying a marked advance in the purity of the juice; and in this case, with the percentage of juice identical for both years.

In concluding the subject I can only say that, considering the uniformity which prevails in the apparent teaching of all the results above given, it seems evident either that we have already accomplished something in the improvement of the cane, or else that the season of 1889 instead of being an unfavorable one for sorghum, as throughout the entire State it had the reputation of being, was after all a favorable one in disguise.

The former conclusion certainly seems the more reasonable.

II. Miscellaneous Sorghum Work.

On september 20th, the Station received from Hon. John Hayes, President of the State Agricultural Society, Red Oak, Iowa, a box containing five stalks each of Early Amber and Orange cane for analysis.

They were analyzed next day, Sept. 21st. They had been shipped by Mr. Hayes on the 16th but suffered a delay of one or two days at the express office, and had probably begun to deteriorate before reaching us.

These 10 canes were analyzed individually with the results here stated in averages for each variety.

Early Amber and Orange canes from Red Oak, Iowa:

Averages on five Stalks of Each Variety.

Variety.	Per cent. Juice.	ON THE JUICE.			
		Solids. Brix.	Sucrose, single polarization	Purity coefficient	Glucose.
		per cent.	per cent.		per cent.
Early Amber.	52.10	15.56	10.85	69.73	2.88
Early Orange.	50.60	14.64	8.57	58.54	3.66

Analyses of Eleven Varieties of Sorghum.

Last spring the U. S. Department of Agriculture sent to this Station seed of a number of varieties of sorghum for trial. They were planted as early as the season allowed, but as a rule were hardly mature by the middle of September. On Sept. 16th and 17th seven cleaned stalks (from as many different hills) of each variety were milled and the juice analyzed as usual, with the following results:

Varieties from United States Department of Agriculture.

Varieties.	Per cent. Juice.	ON THE JUICE.			
		Solids. Brix.	Sucrose, single polariza'n	Purity coeffici'nt	Glucose.
		per cent.	per cent.		per cent.
Early Tennessee.	56.4	10.38	2.77	26.68	5.62
White Africa	56.9	15.76	9.30	59.01	4.63
Red Liberian	63.6	14.77	6.16	41.70	6.27
Honey Dew	51.4	15.93	9.24	58.00	4.04
Cameron's Early	54.9	11.53	6.00	47.88	4.80
Price's New Hybrid	50.4	15.26	6.84	44.82	5.41
Deutcher's Hybrid	58.4	16.39	8.42	57.96	6.04
Late Orange	59.4	13.23	6.63	50.58	4.62
Folger's Early	58.0	16.03	10.31	62.45	3.65
Swan's Early Golden	60.8	16.51	11.56	72.11	2.54
Sorghum Saccharatum, originally from S. Africa	54.9	15.75	9.43	59.87	4.40

It is seen at a glance that in adaption to this climate none of these varieties are at all comparable with the two

good varieties we already have, Early Amber and Early Orange.

III. Sugar House Work.

The attempt made at this Station last season to make sorghum sugar by the socalled "Jennings Process" has been fully reported upon by Director Speer (Bulletin No. 7) in all its phases except the chemical, therefore I will confine my statements strictly to that branch of the experiment.

I may premise, however, by saying that none of our selected cane—which I have shown to be of excellent quality—was used in the manufacturing experiments; the intention was to use it for that purpose as soon as the work of seed selection by analysis was completed, but the early frost effectually vetoed that plan.

Of the lots of cane brought in by farmers, only eight were tested as to quality, but it is probable that these eight lots fairly represent the entire delivery for the season. Eight or ten average canes from each lot constituted the sample on which the test was made.

Cane furnished by Farmers.

On the Juice:

Nos.	Solids. Brix.	Sucrose, single polarization.	Purity coefficient.
	per cent.	per cent.	
1	14.5	6.48	44.7
2	17.8	10.95	61.5
3	16.8	11.60	69.0
4	14.9	7.81	52.4
5	17.4	11.60	66.6
6	17.9	7.24	40.5
7	17.4	10.40	60.0
8	16.7	9.35	56.0
Average	16.7	9.43	56.5

From cane of the quality here exhibited it would have been strange indeed if the attempt to make sugar had been successful.

Extraction of the Cane Chips.

Analyses of the exhausted chips from six charges gave figures for sucrose ranging from .77 to 2.70 per cent., with a mean of 1.96. This is of course far from satisfactory ex-

traction; but it must in fairness be said that the cane was poorly chipped; that in consequence of the novelty of the process, extraction was not always executed in a systematic manner, and finally that extraction was always much more thorough at the the top of the cell (12 feet high) than at the bottom.

Mill and Diffusion Juices Compared.

Samples of cane chips were on certain days milled and the juice analyzed. It cannot of course be known whether these comparatively small samples, taken at one time in the day only, truly or even approximately represent the average for the day; therefore too sweeping conclusions should not be drawn from the comparison of these mill juices with the diffusion juices for the same days:

Mill and Diffusion Juices Compared.

	Solids. Brix.	Sucrose, single polarizat'n	Purity coefficient.	Glucose.
	per cent.	per cent.		per cent.
Sept. 27th—				
Mill Juice	13.8	6.44	46.8	5.23
Diffusion Juice	10.3	4.29	41.7	4.07
Sept. 28th—				
Mill Juice	18.1	10.65	58.8	5.45
Diffusion Juice	14.6	7.70	52.7	2.63
October 1st—				
Mill Juice	13.6	7.70	56.6	4.51
Diffusion Juice*	13.7	7.05	51.2	4.14

*This juice had been evaporated somewhat before sample was taken for analysis.

Other diffusion juices which were tested gave results as follows:

Solids. Brix.	Sucrose, single polarization.	Purity coefficient.
per cent.	per cent.	
14.1	8.37	59.4
14.8	6.80	46.0
15.9	6.71	42.1
15.8	6.52	41.3
11.9	6.54	55.0

It is evident that from such juices as these crystallized sugar could not be obtained.

IV. Sorghum Syrup Adulteration.

In Bulletin No. 5 the Station offered to examine and report upon any samples which might be sent in, by residents of the State, of alleged "sorghum syrup" suspected of adulteration, provided the sender would furnish a history of the sample so far as it could be learned and give name and address of the seller. Only one person has availed himself of the offer. Mr. C. M. Mather, of Clarksville, sent a sample which was purchased of ——— ———, of ———, Ia, as genuine sorghum syrup.

Polariscopic examination, by means of a Schmidt and Hænsch instrument giving readings in sugar percentage, furnished the following data:

On a normal solution, ie, 26,048 gms in 100 cc.

Direct Reading, *taken as sucrose*, = 110.4 per cent.

After inversion, Reading (corrected) at 23° C. = +90.3°. [Means were not then at hand for polarizing at 87° C.]

By evaporation of a portion, total solids were found to be 73.53 per cent.

On account of the great variability in the proportions of maltose, dextrin and dextrose present in commercial glucose, it is impossible from the above data to tell just how much of the adulterant (glucose) had been used in this case; but the figures are amply sufficient to prove *gross adulteration* probably amounting to fully one-half on the dry solids of the syrup as sold.

For comparison, the figures obtained on a genuine sorghum syrup (made by a farmer near Ames) may be of interest.

Total solids, 66.47

On a normal solution,

Direct Reading, *taken as sucrose* = 44.18 per cent.

After inversion, Reading (corrected) at 23° C. = +2.29°.

These two sets of figures tell the difference between the samples more plainly than words.

The offer above referred to is still open to all residents of the State; and the Station now possesses apparatus for making more thorough examination of such substances.